Deer in Arizona and New Mexico: Their Ecology and a Theory Explaining Recent Population Decreases

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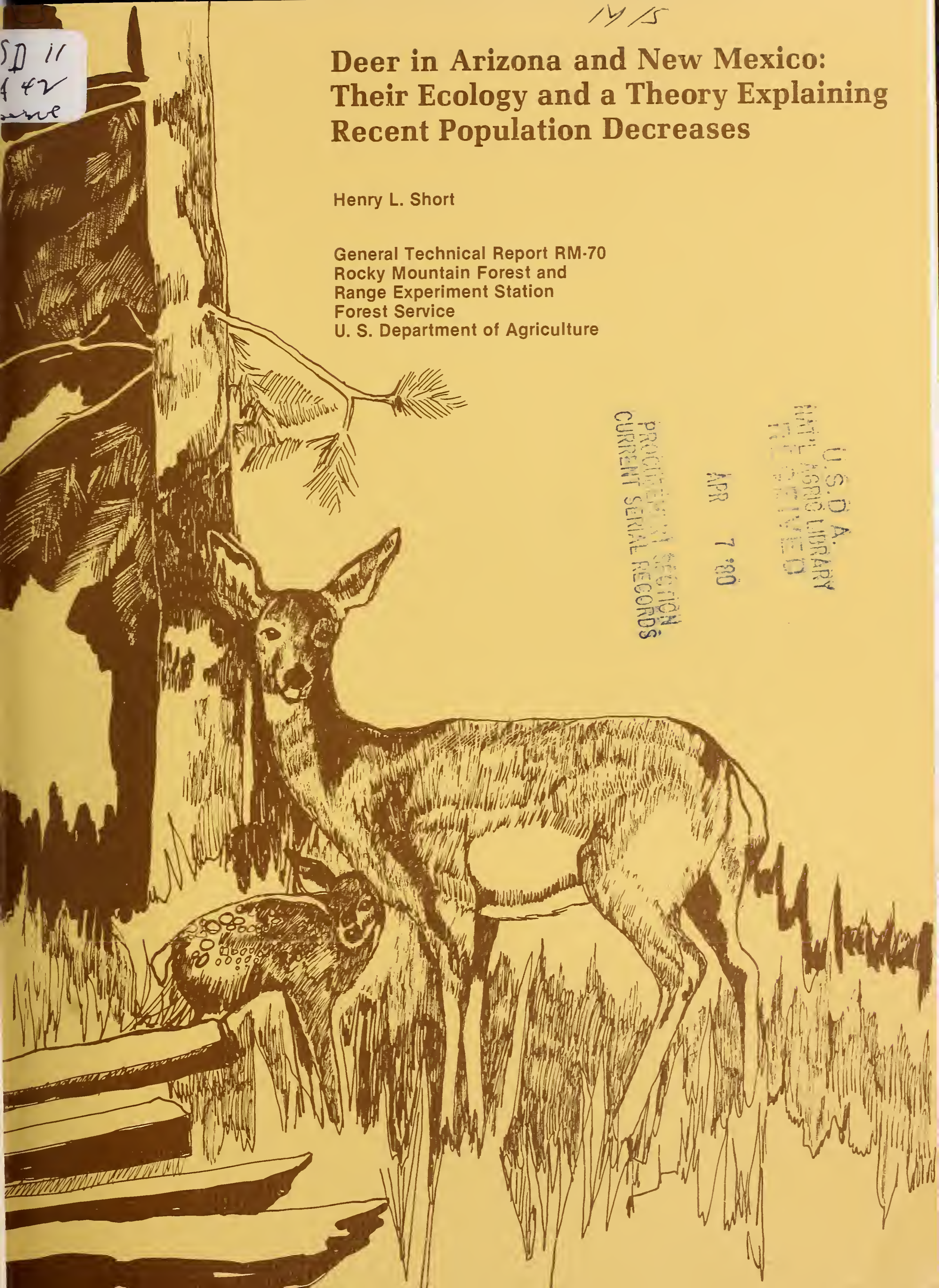

Abstract

The hypothesis that declines in southwestern deer populations from late 1950's levels have been caused by relatively low fawn recruitment rates (because of habitat quality) combined with increased female mortality (because of antlerless deer hunting) is supported by computer simulations of the dynamics of southwestern deer herds.

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SUGGESTIONS FOR DEER MANAGEMENT IN THE SOUTHWEST

Data Gathering Techniques

Accurate information about the population structure of deer herds is essential to effective management of the resource. Quantitative information about deer in many areas of the Southwest is difficult to obtain because deer managers are dealing with large, often inaccessible areas with limited deer and hunter populations. Still, quantitative information is so important in terms of gaining insight about herd structure that great effort should be expended to gather relevant data. The data, if wisely used in computer simulations, can alert the deer manager to trends in herd populations or potential responses to proposed hunting options in time to prevent range problems or decimated herds.

Deer managers often rely on three types of field-collected information in order to assess their resource—large scale surveys of deer indicators, biological check stations, and actual observations of deer. In practice, the deer manager in the Southwest routinely has had little quantitative information upon which to base his herd management decisions.

The information available from large-scale surveys of deer indicators, such as pellet group counts and deer forage surveys, varies in quantity and quality for the different deer herds of the Southwest. At best, however, procedures such as counting pellet groups only indicate population trends, are subject to the vagaries of weather, and provide no information about the sex-age structure of a deer herd.

Game managers in the Southwest rarely get substantial biological information from biological check stations during the hunting season. For example, the New Mexico Game and Fish Department collected incisor teeth (to determine the age structure of harvested deer) at check stations in only 4 of 57 game management units in 1974. Only limited collections of incisor teeth, field dressed weights, and antler measurements were made in Arizona during 1974. Some useful sex-age information about deer herds can be obtained from check stations, since most human contact with deer occurs during the hunting season. Ovarian information yielding estimates of fawn production, herd age structure, and physical condition of does can be assessed if does are harvested. Estimates can be made of the size of the deer herd, and trends in herd populations can be suggested from data relating buck or deer kill to measures of hunting effort. Analyses of the age structure of killed deer, coupled with suitable computer simulations, can indicate whether survival of particular age classes such as fawns or yearlings is adequate or low.

Managers with both the New Mexico and Arizona Game and Fish Departments seem to rely on surveys of fawn:doe ratios after hunting season as a biological indicator of the structure and productivity of deer herds. Such surveys are generally accomplished by driving designated routes in as consistent a manner as possible between years to reduce sampling bias. Climatic conditions, deer behavior, and human workloads may greatly affect the number of deer observed. Useful estimates of trends in doe populations are probably not obtained. Fawn:doe ratios can be quite useful, however, if these data are supplemented by information about the survival rates of different age-classes of deer.

Deer herds in the Southwest were at relatively high levels in the late 1950's and declined until the late 1960's, apparently because of low fawn recruitment rates and the increased mortality of adult does caused by the hunting of antlerless deer. Lack of precise biological information about deer productivity and survival caused deer managers to inadvertently overlook trends in deer populations. It seems unfortunate that the quality of biological information presently being gathered in the Southwest may not allow present deer managers to be any more perceptive about trends in their statewide deer herds.

Management Strategies

Because deer productivity in the Southwest may be fundamentally limited by nutritional factors apparently associated with seasonal precipitation, deer management may be limited to optimizing useful vegetation in deer habitats,

minimizing herbivore competition, minimizing controllable sources of mortality, and harvesting highly productive deer herds in different ways from herds with low productivity.

Overgrazing by domestic herbivores in all vegetation zones can be deleterious to deer; enforcing grazing allotments at legitimate carrying capacity is a necessary management tool. Feral herbivores, such as wild burros, should be controlled when they are numerous enough to destroy vegetation needed by deer or to foul water catchments essential to wildlife. Predator control measures are justified if it can be demonstrated that wild carnivores adversely affect deer numbers and if herds are not already at range carrying capacity.

Continued urbanization has an adverse impact on deer. Unrestricted land development around cities and towns causes rapid deterioration of habitat. Mining activity, increased recreational use of public lands, and disturbances by off-road vehicles may also be detrimental to deer. Deer herds using Indian reservations as part of their range are difficult for state game and fish agencies to manage because the state agencies have no jurisdiction over the deer harvest and little input into habitat manipulation.

Some of the vegetation manipulation done on southwestern ranges to increase deer-carrying capacity has been found wanting. The cabling or chaining of large tracts in pinyon-juniper woodlands is expensive management. Benefits in terms of increased domestic herbivore production and water conservation frequently do not equal the cost of the woodland conversion (Clary et al. 1974). Furthermore, large block clearing of woodlands is detrimental to deer and elk (Short et al. 1977). Control of pinyon-juniper woodlands, done on a localized, prescription basis, can be beneficial; numerous small clearings are useful in areas of heavy wildlife use and where a dense tree overstory has reduced midstory shrub and understory forage production.

Browse production can sometimes be dramatically improved with prescription cutting. The proper seeding of browse, forbs, and grasses used as deer food can increase the abundance and variety of foods available to deer. Controlled burning or wildfires in dense pinyon-juniper woodlands can kill the overstory and contribute to an enriched grass and forb understory but may also destroy the valuable shrub midstory (McCulloch 1969).

Browse species in the chaparral brushlands may produce abundant crown sprouts following fire. This new growth is succulent, high in nutrients, and heavily used by deer (Swank 1956a). The increased nutritive value is lost several years after burning. Control of chaparral may provide a broader selection of foods and an increased midwinter supply of green forbs for deer, but control should not be extensive enough to destroy habitat by depleting available cover (Cable 1975).

Small clear-cuts, reseeded and interspersed with montane conifers, improve the vegetative composition and total forage quality (Neff 1974). Several studies have indicated the increased forage production and deer use which follows the disturbance or cutting of mature stands of trees (e.g., Patton 1969, Reynolds 1962). Vegetation manipulation to encourage the production of new growth in aspen stands improves deer habitat in subalpine forests (Reynolds 1969).

Manipulating blocks of forest and woodlands to provide a diverse plant community and increased production of foodstuffs is good deer management. Restricting competition from other herbivores, minimizing the disturbance of urbanization, and utilizing special environmental aids, such as watering areas, all have favorable impacts on southwestern deer. The situation remains, however, that the most favorable deer habitats in Arizona and New Mexico cover only about one-third of the land area and that precipitation patterns may modify the absolute productivity of some of these lands.

INTRODUCTION

Hunting antlerless deer has been used to control deer populations when deer herds have exceeded range-carrying capacity, and to provide an additional hunting resource when populations and reproductive successes are high and hunter demand is great. Deer populations can be sustained with limited hunting of antlerless deer under conditions of high fawn productivity, good fawn survival, and carefully prescribed rates of hunting mortality. Too often the hunting of antlerless deer has been applied to herds where fawn production and survival rates are unknown and where hunting mortality has not been carefully monitored. This occurred in New Mexico and Arizona in the late 1950's and 1960's. The resulting declines in deer populations were of greater magnitude and of greater duration than anticipated. Computer simulations of population growth assuming various survival rates for fawns, does, and bucks support the theory that hunting antlerless deer can produce drastically different long-term population effects in different herds.

As theorized, younger does in many portions of the Southwest bear relatively few fawns. In addition, only modest proportions of all fawns seem to survive to enter fawn-producing age classes. The ultimate cause of these limited rates of deer production is hypothesized to be the nutritional quality of forages which results from the soils and climate of the region. The important resource limitations suggested in this paper must be considered for statewide deer herd management programs to be successful.

The first part of this paper suggests tactics for managing deer in the Southwest. The second portion contains an analysis of the quality of deer habitats in the Southwest and an analysis of productivity and population dynamics of southwestern deer. The last part is a strategy for using the hunting of anterless deer to control herd population.

DEER OF THE SOUTHWEST

Distribution

There are four subspecies of deer of the genus *Odocoileus* in New Mexico and Arizona. About 90% of the total deer numbers may be mule deer (*O. hemionus*), with the remainder white-tails (*O. virginianus*). The few whitetails in eastern and central New Mexico belong to the subspecies *O. v. texanus* (Lang 1957, Hoffmeister 1962). The Sonoran or Coues whitetail (*O. v. couesi*) occupies suitable habitat in localized areas of southwestern New Mexico and southern and central Arizona (Hall and Kelson 1959). Arizona has perhaps 32,000 whitetails (Wilcox 1977), which may be three times the number found in New Mexico.

The desert mule deer (*O. h. crooki*) occupies chaparral and pinyon-juniper woodlands and the desert flatlands in the southern one-third of New Mexico (Lang 1957) and chaparral and desert scrub ranges from west central to southeastern Arizona (Hoffmeister 1962). The Rocky Mountain mule deer (*O. h. hemionus*) occupy mountain ranges and mesas in the northern two-thirds of New Mexico and a broad area north of a line from northwestern to east-central Arizona. Its range is generally delineated by the extension of pinyon-juniper growth into grasslands and brushy draws. Summer ranges extend from above timberline to foothills and valleys, and winter range extends to lower elevations depending on weather conditions. There are perhaps 150,000 mule deer in Arizona (Wilcox 1977) and 270,000 mule deer in New Mexico.

Deer are unevenly distributed in both states (fig. 1). Deer in Arizona are generally concentrated in the northern Kaibab, Mogollon Rim, White Mountains, and central and southeastern mountains; deer in New Mexico are concentrated in south central, northern, and southwestern game management units.

Habitat and Nutrition

Arizona and New Mexico contain varied habitats that are extensions of the Rocky Mountains, Great Plains, and the Great Basin of the United States and of the Sierra Madre Occidentals, the Chihuahuan Desert, and the Sonoran Desert of Mexico.

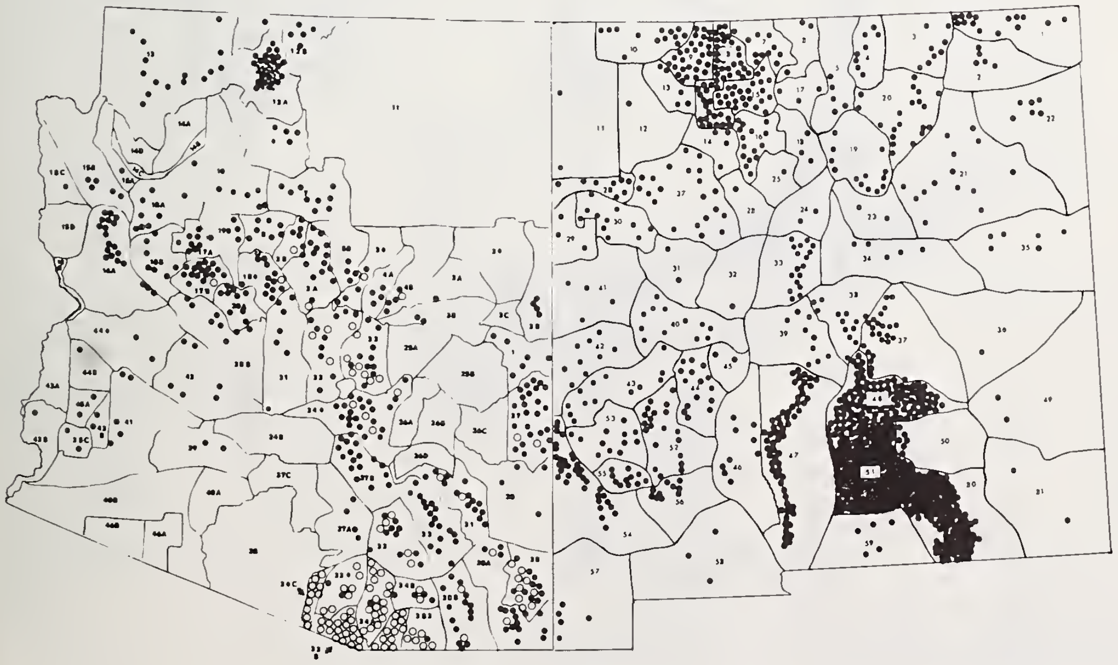

Figure 1.—Rate of deer kill in Arizona and New Mexico varies by game management unit. Each symbol represents 25 deer legally killed in 1974. For Arizona, large circles represent buck white-tailed deer, and small dots represent female mule deer killed on the north Kaibab. Large dots in both states represent buck mule deer. Game management units 11, 25, and 26 in Arizona consist of major Indian reservations.

There is, across these varied habitats, an important association between seasonal and annual aridity, soil mineral content, and forage quality. Low forage quality can routinely occur within forages on many southwestern deer habitats, and these deficiencies can adversely affect southwestern deer herds by lowering fecundity, fawn survival, and recruitment. The resulting low productivity seems characteristic of many southwestern deer herds.

Vegetation

Description

Areas where deer kill is greatest are presumably a function, among other things, of the size of deer populations and habitat quality. Buck deer kill during 1975 in the individual game management units in Arizona and New Mexico was regressed on the square miles of the different vegetation types within those game management units and compared with the distribution of those major vegetation types within the two states (fig. 2). Results of the regression analysis (table 1) suggest the deer population is concentrated in the following vegetation types: interior chaparral, madrean evergreen woodland (oak woodland communities), great basin conifer woodlands (pinyon-juniper communities), and petran montane conifer forest (ponderosa pine). These woodland and forest communities important to deer occur on about one-third of the land area of both Arizona and New Mexico (table 2).

Table 1.—The relationship of total mule deer buck kill (1975) and the area of each of the vegetation communities present within each different game management unit listed in the order in which the different habitat vegetation types were entered into significant multiple regression equations. Each variable below increased the R^2 value by at least 2%

Variable	R^2 value
Arizona	
Interior chaparral	0.18
Madrean evergreen woodland (oak communities)	0.26
Petran montane (ponderosa pine) conifer forest	0.34
Great Basin conifer woodland (pinyon-juniper communities)	0.37
Chihuahuan desertscrub	0.39
Petran subalpine conifer forest (spruce-fir)	0.41
New Mexico	
Interior chaparral	0.25
Great basin conifer woodlands (pinyon-juniper communities)	0.31
Petran montane (ponderosa pine) conifer forest	0.35
Madrean evergreen woodland (oak communities)	0.38

Nutrition

Studies of the food habits of mule deer and white-tailed deer in the Southwest indicate deer consume a great variety of plant materials (table A1). Other food habit studies will undoubtedly extend this list. Deer depend on perennial woody shrubs and trees for leaves, buds, succulent twigs, and fruit. Hardened twigs of limited nutritional value may be eaten during periods of environmental stress when other, more palatable foodstuffs

Figure 2.—Distribution of biotic communities in Arizona and New Mexico that comprise important deer habitat. Montane conifer forest equals the Petran montane conifer forest (ponderosa pine), pinyon-juniper woodland equals the great basin conifer woodland, and chaparral and Mexican oak-pine woodland equals interior chaparral and madrean evergreen woodlands listed in tables 1 and 2.

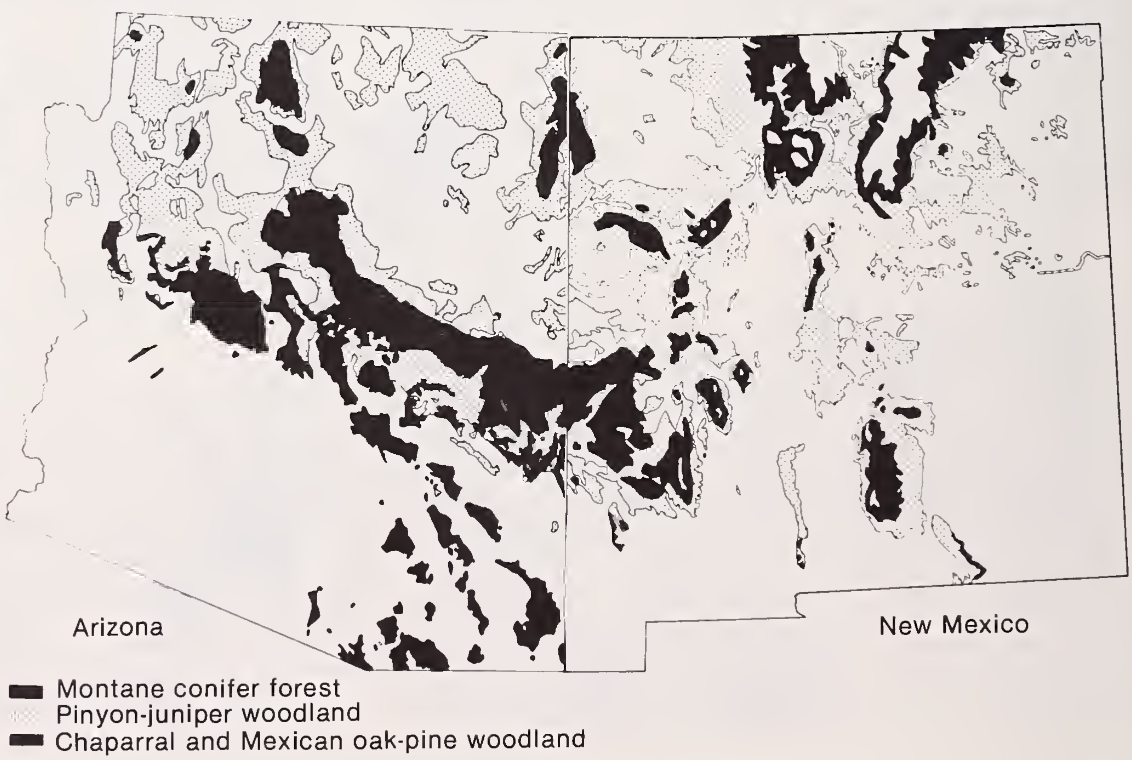

Table 2.—Approximate percent composition (to nearest 0.5% of the total land area) of vegetative communities in Arizona and New Mexico. Values estimated from map prepared by Brown et al. (1977)

Biotic communities	Arizona	New Mexico
Chihuahuan desertscrub	1.5	8.5
Sonoran desertscrub-lower		
Colorado River subdivision	17.0	0
Arizona Upland subdivision	14.0	0
Mohave desertscrub	4.5	0
Great Basin desertscrub	6.5	1.5
Semidesert grassland	8.0	21.0
Plains and Great Basin grassland	15.5	35.5
Interior chaparral	4.0	0
Madrean evergreen woodland	3.0	1.0
Great basin conifer woodland (pinyon-juniper)	18.0	20.5
Petran montane conifer forest (ponderosa pine)	7.5	9.0
Petran subalpine conifer forest (spruce-fir)	0.5	3.0
Alpine tundras	0	0
Subalpine grassland	0	0
	100.0	100.0

are unavailable. Deer seasonally eat forbs, mushrooms, fruits, nuts, and some green grass.

Leaves of woody plants frequently comprise the most important dietary item for deer across seasons in a variety of habitats (table A2). Forbs are seasonally important in winter and spring in chaparral-desert habitat, in summer in ponderosa pine habitats, and in spring and summer in semidesert grasslands and pinyon-juniper habitats. Cactus fruits are a significant portion of the autumn and winter diet of mule deer in semidesert grasslands (Short 1977).

A few nutritional studies have been accomplished with southwestern deer to help explain the observed fluctuations in deer numbers. The crude protein, phosphorus, and in vitro dry matter digestibility values for 25 forage samples composited to duplicate the seasonal diet of deer from several ranges are listed in table 3. The letters F (fair) and P (poor) appear after nutrient values lower than those cited as desirable by Urness (1973). White-tailed deer in chaparral habitats are dependent on forage of only fair digestibility from May to September, of only fair phosphorus content from July to January, and of only fair protein levels from July to September. Mule deer habitats frequently provide forage of only fair-poor phosphorus content throughout much of the year. Forage digestibility is only fair in chaparral and desert grassland habitats from October to December. Digestibility is only fair from July to September and poor from January to March in pinyon-juniper habitats. Forage protein levels for mule deer in pinyon-juniper habitats are only fair from July to December. Forages deficient in

Table 3.—Some nutritional values: percent crude protein, phosphorus, and in vitro dry matter digestibility of forages similar to those in ruminal contents of deer collected at the different seasons from different habitats. The letters F and P after a value indicate that value is only of fair or poor quality as suggested by standards listed by Urness (1973, p. 41). The brackets indicate months represented in seasonal data.

	Habitat type	Authority	Factor	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
White-tailed deer	Chaparral	Urness (1971)	Protein	11		13			12		9 F		12		10
			phosphorus	0.23 F		0.31			0.28		0.22 F		0.21 F		0.22 F
			digestibility	42		52			35 F		37 F		57		47
Mule deer	Chaparral and desert grassland	Urness (1971)	Protein	11		13			12		14		12		10
			phosphorus	0.21 F		0.29			0.25		0.23 F		0.26		0.16 F
			digestibility	40		51			43		42		35 F		34 F
Mule deer	Ponderosa pine	Urness (1975)	Protein					25	17	16	14	10			
			phosphorus					0.48	0.24 F	0.19 F	0.19 F	0.24 F			
			digestibility					68	54	56	46	49			
Mule deer	Desert grassland	Short (1977)	Protein	10 F			10				10 F		10		
			phosphorus	0.15 P			0.23 F				0.16 P		0.15 P		
			digestibility	54			52				48		45		
Mule deer	Pinyon-juniper	Boeker et al. (1972)	Protein		12			11			9 F			9 F	
			phosphorus		0.19 F			0.26			0.17 F			0.18 F	
			digestibility		23 P			45			37 F			43	

phosphorus are especially deleterious to deer since insufficient dietary phosphorus causes decreased inorganic blood phosphorus levels, depleted mineral content in bones, diminished rate of weight gain and milk production, and a possible reduction in animal fertility (Church 1971). Diets of low protein content cause slow physical development and low reproductive success in deer (Verme and Ullrey 1972).

Soils

Description

The vegetative types most associated with deer in New Mexico and Arizona generally overlay the mesic semiarid (mean annual soil temperature 8-15° C and annual precipitation of 25-41 cm) and the mesic subhumid and frigid subhumid soils (mean soil temperature less than 15° C and precipitation greater than 41 cm) (fig. 3, table 3). These soils tend to occur at higher altitudes and are characterized by being fairly well developed, leached, and acid (Maker et al. 1974). These soils types occur on about 32-35% of the land area of Arizona and New Mexico (table 4).

Influences on Nutrition

The nutrient quality of plants is directly affected by the nutrient content of the soil (Laycock and Price 1970). Soil moisture available for plant growth, which can affect both yield and chemical composition, varies extensively in Arizona and New Mexico (figs. 4 and 5).

Table 4.—Approximate area (ha) of major soil types in Arizona and New Mexico. Data after Maker et al. (1974) and estimated from the supplement to Arizona General Soils Map (U.S. Department of Agriculture 1975)

Soil types	Arizona	New Mexico
Light colored soils of warm desertic region (hyperthermic arid, thermic arid, and thermic semiarid)	16,521,700	8,002,400
Light colored soils of cool desertic region (mesic arid)	3,569,800	1,147,700
Moderately dark colored soils of uplands (mesic semiarid)	5,339,900	6,008,900
Moderately dark and dark colored soils of the mountainous region (mesic subhumid and frigid subhumid)	4,071,200	5,142,500
Moderately dark colored soils of east central plains	0	7,609,100
Dark and moderately dark colored soils of high plains	0	3,192,600
Total	29,502,600	31,103,200

The warm, dry climates with long, hot summers, common to 16,500,000 ha in Arizona and 8,000,000 ha in New Mexico, facilitate the oxidation of organic and inorganic materials from the light-colored soils. Soils become low in organic material and soil aggregates are frequently coated with iron oxides (U. S. Department of Agriculture 1964). These soils tend to accumulate thick horizons of calcium carbonate, and high levels of calcium, aluminum, or iron in the soil diminish the availability of phosphorus to plants, even when soil phosphorus is present (Reed 1973).

Total nitrogen in arid and semi-arid soils is inversely related to mean temperature (Jenny 1928). Very low levels of nitrogen are present in warm desert and semi-desert soils (Stevenson 1965). The nitrogen content of soils tends to increase as temperature decreases and precipitation increases in the transition from desert to mountains. Soils on north-facing slopes may have a higher nitrogen content than soils on south-facing slopes (Stevenson 1965). Vegetation growing on these wetter montane habitats would presumably have higher nitrogen values. Deer forage collected from ponderosa pine habitats during summer tends to have higher crude protein contents than forage collected from drier habitats (table 4).

Plants in early stages of growth have a high protoplasm/structural components ratio and the ability to store a variety of nitrogen compounds for future use (Viets 1965). During later developmental stages, the nitrogen is transported from leaves and stems into developing seeds or storage roots. Plants growing where soil nitrogen is deficient tend to have more carbohydrate production in above-ground tissues. When deficiencies are especially severe, no seed production occurs (Viets 1965). If only enough nitrogen is available for seed production, foliage eaters will be adversely affected because seeds accumulate nitrogen at the expense of other plant parts.

Precipitation Patterns

Description

The areas most heavily populated with deer tend to be areas with greater precipitation, lower evapotranspiration rates, and decreased soil moisture deficits. These climatic characteristics are illustrated in figures 4 and 5 for a variety of Arizona and New Mexico locations. Soil moisture deficits presumably reflect potential water stress for plants. Water stress, in turn, affects nearly every aspect of growth (Kramer 1969) including anatomy, morphology, physiology, and biochemis-

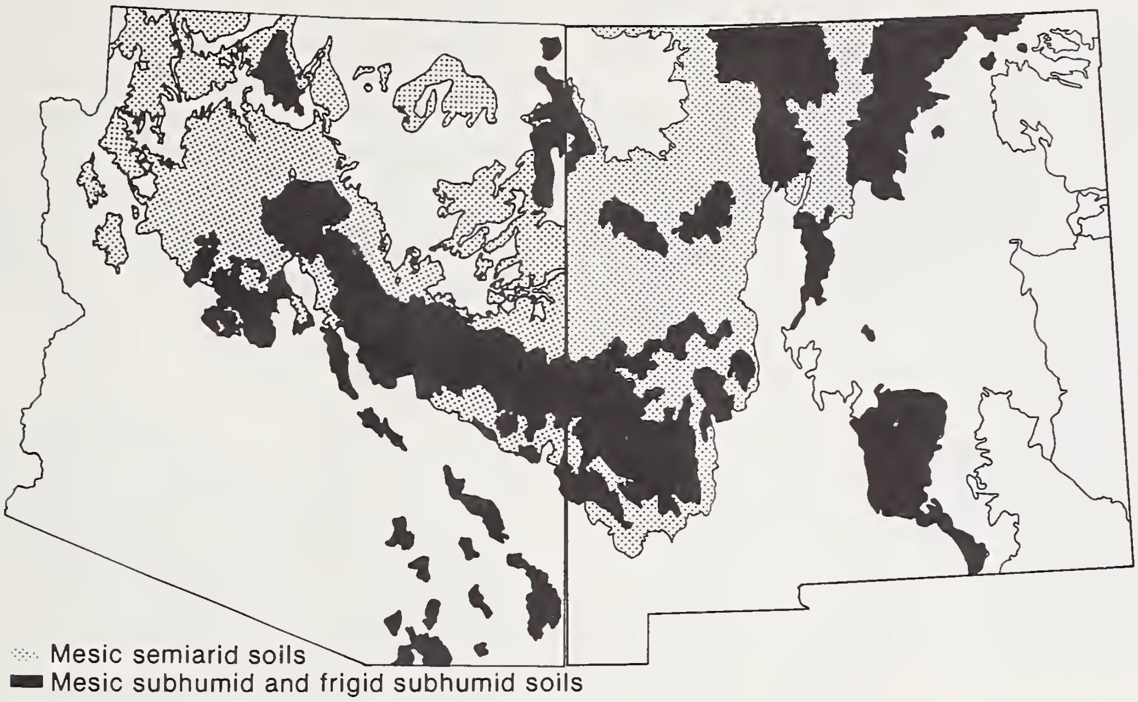

Figure 3.—Distribution of the major soil groupings occurring in important deer habitats in Arizona and New Mexico.

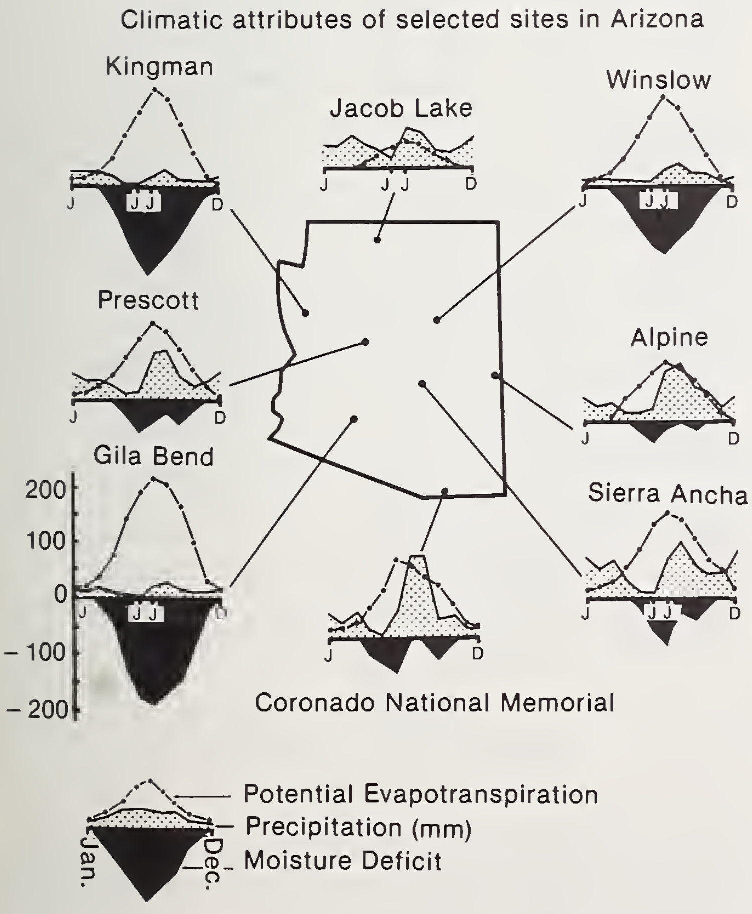

Figure 4.—Climatic characteristics of selected Arizona sites (after procedures in Thornwaite and Mather 1957).

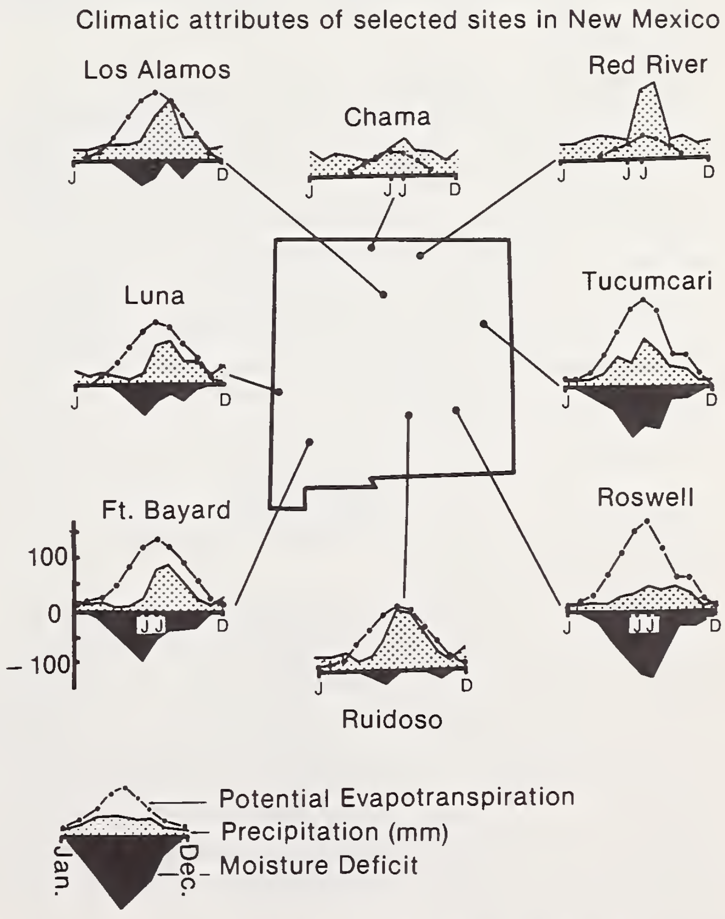

Figure 5.—Climatic characteristics of selected New Mexico sites (after procedures in Thornwaite and Mather 1957).

try. These changes, in turn, affect the seasonal presence, quantity, nutritional quality, and palatibility of food plants.

The non-winter months are critical to deer throughout the Southwest because of the combined deleterious effects of seasonal droughts and elevated temperatures on vegetation. Severe winter weather, on the other hand, is confined to high mountain ranges and can be avoided with seasonal moves by deer to lower elevations where the extensive woodlands provide necessary food and cover.

Patterns of seasonal precipitation vary throughout Arizona and New Mexico (figs. 4 and 5). Precipitation is highest in the summer and lowest in winter in eastern New Mexico and highest in summer and lowest in spring in southwestern New Mexico. The spring drought in Arizona is progressively more severe in the central and western portions of the state and at lower elevations (fig. 6).

The routinely severe spring drought which occurs over much of Arizona may be an important influence on the quality of deer habitat in that state, especially in comparison to north-central and south-central New Mexico. Spring and summer soil moisture deficiencies, more extensive in Arizona than New Mexico (figs. 4 and 5), may affect the quality of deer habitat to an even greater degree when they follow winters of limited precipitation.

Seasonal precipitation affects forage production in the Southwest and consequently influences deer production. Summer precipitaiton affects the production of annual and perennial grasses, mushroom growth, and the regrowth of shrub tissues during the critical production season for deer (fig. 7). Numerous studies have emphasized the vulnerability of the neonate fawn and the importance of adequate nutrition for the doe to increase the likelihood of fawn survival during parturition, lactation, and weaning. In Arizona and New Mexico only subalpine and montane coniferous habitats have precipitation rates which exceed potential evapotranspiration during this critical season.

Autumn and winter precipitation affects the production of cool season annuals and perennials (fig. 7), especially in elevations below 1,800 m. During these seasons, deer consume succulent forbs and grasses, in addition to making heavy use of evergreen browse (table A1). Autumn and winter are seasons of maintenance for deer in general—conception and early gestation for does, post-weaning stress and growth for fawns, and rut for bucks (fig. 7).

Adequate spring moisture is necessary for good shrub growth, subsequent fruit production on woody plants, and the production of annual and perennial grasses and forbs (fig. 7). This is a critical production period for southwestern deer, with does recovering from the stress of winter and needing adequate nutrition to ensure successful parturition (Verme 1962). For surviving fawns, spring is both a recovery period and a time of growth and development; for bucks, spring is a recovery period and a time of antler regenesis.

Influence on Nutrition

Soil moisture is often abundant early in the growing season when herbaceous plants have high nutritive quality and grow rapidly. As soil moisture diminishes and temperatures increase, herbaceous plants mature and dry and nutritive value falls.

The forage values of different plant types are similar at the inception of growth but vary with continuing growth. Forage is high in nutrients such as carotene, phosphorus, and crude protein during initial growth and for some time thereafter. The ratios of leaf tissue to other plant tissue usually diminish with maturity. Coincidentally, carotene, phosphorus, and crude protein levels and digestible energy become reduced, and fiber levels increase.

Shrub tissues generally retain high carotene values throughout the year, while carotene contents in grasses and forbs decline to very low levels with plant maturity. Digestible proteins in shrubs, forbs, and grasses all decline with maturity. Levels common to mature forbs and grasses may be inadequate for maintenance of deer. The phosphorus content of grasses is generally deficient after seed formation (Cook 1972). Phosphorus deficiencies are so common in mature grasses on western ranges that supplements are recommended to maximize livestock production. In xeric habitats plants mature more quickly, producing less dry matter and nutrient deficiencies that occur sooner and last longer. Leaching of mature or dry herbaceous tissues by rain often causes large decreases in protein, phosphorus, ash, and carotene contents. Some leaching of nutrients and minerals may also occur from growing vegetation (Laycock and Price 1970).

POPULATION DYNAMICS

Deer herds on the xeric ranges of the Southwest may have an inherently lower productivity rate than herds in other areas of the West. Few experimental studies of deer productivity in Arizona and New Mexico have documented this

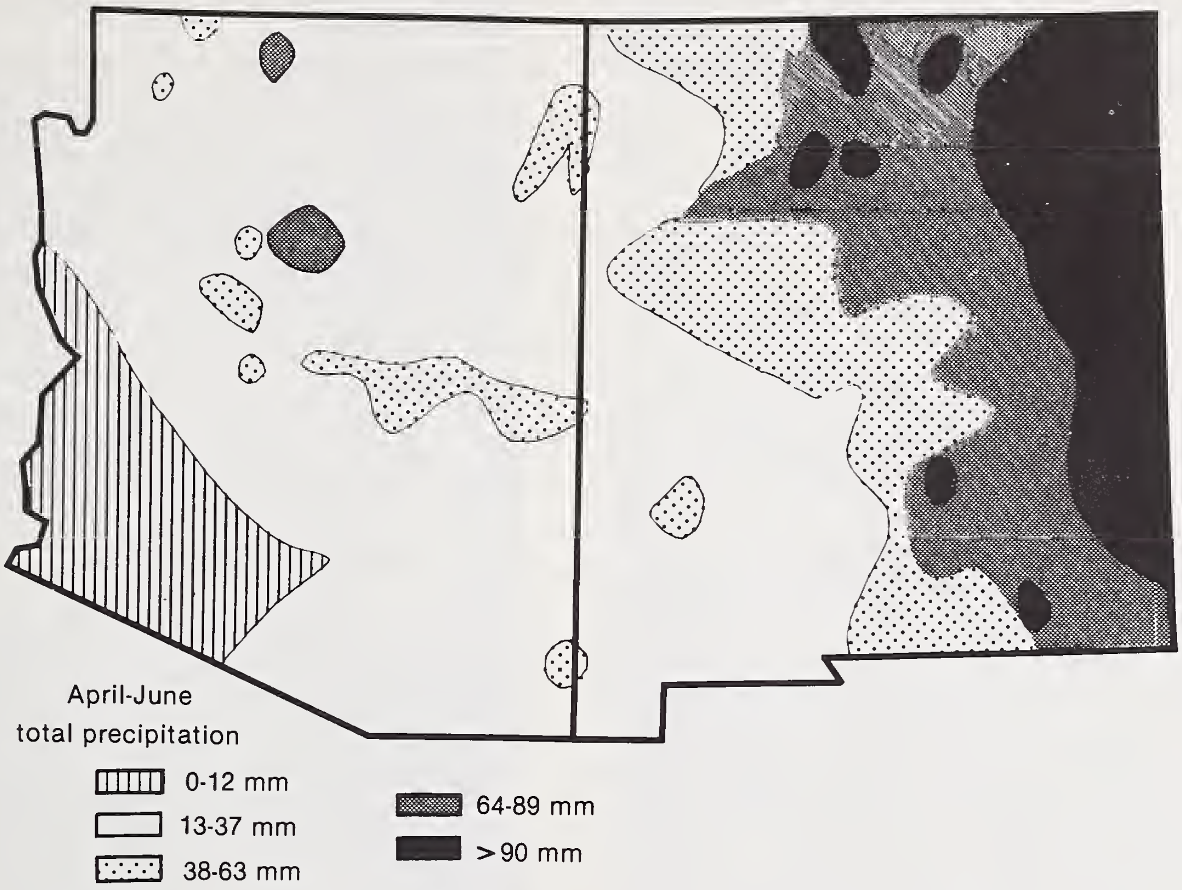

Figure 6.—Spring precipitation patterns in Arizona and New Mexico.

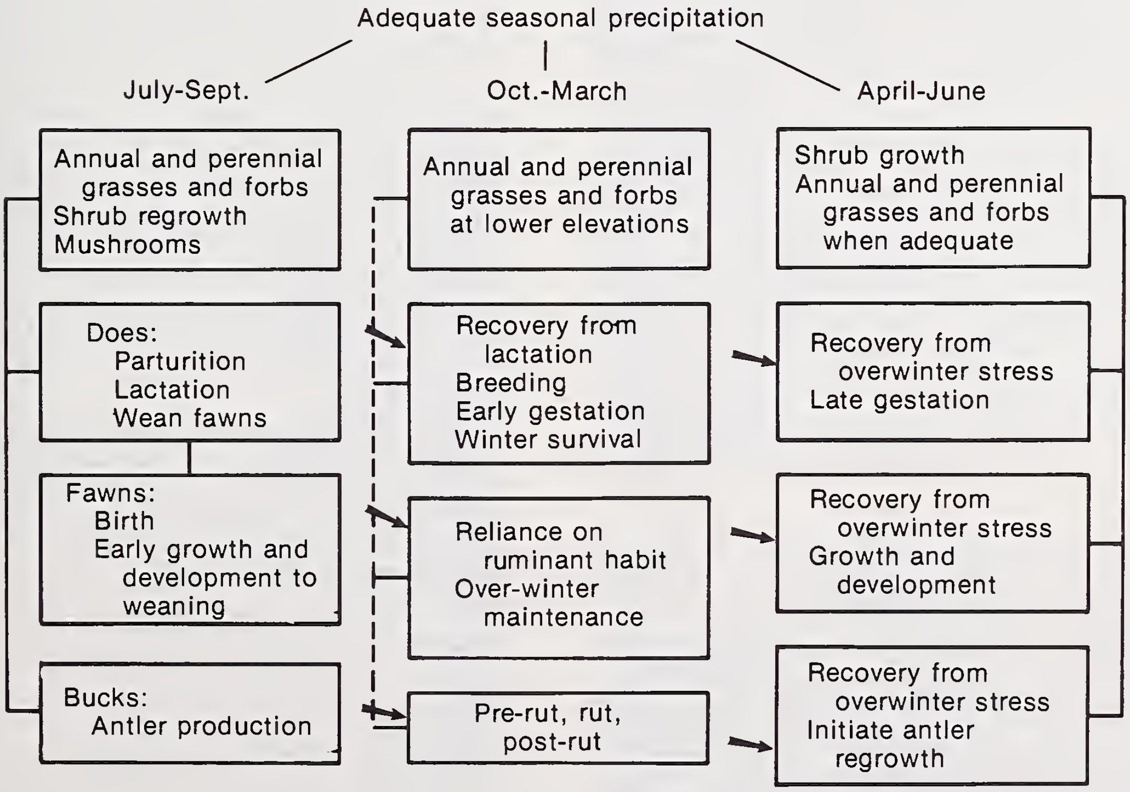

Figure 7.—The relationship of seasonal precipitation and deer production in the southwest.

generalization, so the routine analysis of production rates in different herds would immeasurably aid the understanding of deer herd dynamics in the Southwest.

Measuring Production

Information from Reproductive Tracts

Production rates of white-tailed deer in Arizona, mule deer in Arizona and New Mexico, and mule deer in Utah have been estimated from data gathered since the 1950's largely by personnel of the state game and fish departments. These data are presented in table A3.

Reproductive tracts were examined from does whose ages were estimated by tooth eruption and wear patterns. Ovaries were collected and later examined for corpora albicantia, ductless glands developed within the ovary by the reorganization of the Graffian follicle following ovulation. This count is a liberal estimate of the numer of embryos implanted, which, in turn, is a liberal estimate of the number of fawns born.

Corpora albicantia occur only rarely in 1-1/2-year-old mule deer, from Arizona and New Mexico, indicating almost no natality for 1-year-old does. Counts of corpora albicantia from 27-month-old mule deer does from north and south Kaibab, Mingus Mountain, and the Guadalupe Mountains indicate that 2-year-old does in these areas average less than one fawn. In general, corpora albicantia counts in 3- to 5-year-old mule deer does suggest these deer provide substantial recruitment into the deer herd but average fewer fawns per doe than older, more mature females.

Data for white-tailed deer in the Southwest are limited and not differentiated by doe age classes. The average number of corpora albicantia per doe was about unity, and Day (1960) states that there was no evidence of reproductive activity in female fawns. There is no evidence among these limited data that white-tailed deer in the Southwest will experience the explosive herd increases which sometimes occur in other parts of the country.

Data obtained for good mule deer ranges in Utah include number of fetuses per doe, a more conservative production estimate than corpora albicantia counts. Robinette et al. (1955) reported that doe reproductive tracts containing 792 corpora albicantia yielded 708 fetuses. Doe fawns from Utah, like those in Arizona and New Mexico, produced essentially no fawns. Does on these ranges 1-1/2 years old, however, averaged more than one fetus per doe, and 2-1/2-year-old does produced fetuses at a rate indistinguishable from older females.

Deer production data can be expressed in terms of potential reproductive performance during the doe's first 5 years of life. Mule deer does producing corpora albicantia at the rates observed in the Guadalupe Mountains potentially provide only two-thirds as many fawns in their first 5 years of life as does reproducing at the rate observed for Utah deer. Does from north and south Kaibab and Moqui ranges of Arizona would produce 75, 85, and 92% as many fawns in their first 5 years as Utah does. Differences in fawn survival rates between habitats could further modify these potential recruitment rates.

Interpreting Fawn:Doe Ratios

The ratio of fawns to does is routinely calculated in Arizona and New Mexico from extensive deer surveys conducted in late autumn-early winter following hunting season.

High fawn:doe ratios are presumed to indicate good deer herd recruitment (good production and/or high survival rates) and an increasing resource. Fawn:doe ratios, however, do not necessarily reflect production and survival of fawns. With 100% fawn survival, such widely divergent fawn:doe ratios as 0.25 and 1.25 could be due only to the age structure of the doe population.

A herd of 10% 1-1/2-year-old does that did not breed as fawns, 20% 2-1/2-year-old does averaging one fawn at 24 months of age, and 70% 3-1/2-year-old or older does that had an average of 1.5 fawns per doe the previous summer could provide a fawn:doe ratio of 1.25. A doe population of 80% 1-1/2-year-old does, 10% 2-1/2-year-old does, and 10% older does would yield a ratio of only 0.25. Both populations could increase appreciably in subsequent years if survival rates of yearlings and mature does were high. Thus fawn:doe ratios do not, by themselves, provide enough useful information for predicting population trends.

The proportion of fawns to does varies with the survival rates of fawns, yearlings, and adult does. Table A4 is a computer simulation designed to determine population trends when different doe age classes survive at different rates. Trends are indicated by computing the doe population (yearling and older) after 10 years as a percent of the original doe population. Fawn:doe ratios are dependent on both the age structure of the doe population which determines the numbers of fawns born and the survival rate of the fawns. Fawn survival rates of 80% can yield fawn:doe ratios of 0.70-1.04; survival rates of 60% can

yield ratios of 0.60-0.80; survival rates of 40% can yield ratios of 0.44-0.55; and 20% survival rates can yield ratios only up to 0.28. The highest fawn:doe ratios for a particular rate of fawn survival occur when yearling survival is lowest (i.e., the non-producing doe age class is removed from the calculation). When fawn and yearling survival rates remain unchanged, the fawn:doe ratios vary with the survival rate of mature does and its effect on fawn production. This is indicated in the following discussion.

A fawn:doe ratio of 0.81 occurs when fawn and yearling survival rates are 80% and adult survival rate is 90% (table A4). Under these conditions, the doe population after 10 years is 901% of the original. A fawn:doe ratio of 0.82 occurs when the survival rates of fawns, yearlings, and adults are 80%, 60%, and 70%, respectively, and the doe population is nearly unchanged after 10 years. With fawn survival of 60%, yearling survival of 20%, and adult doe survival of 90% (fawn:doe ratio of 0.80), the doe population after 10 years will be only 75% of the original population. When fawn survival is 70%, yearling survival is 40%, and the survival of adult does is 70%, the fawn:doe ratio is 0.79; but after 10 years the doe population would only be 29% of the original number. Obviously the fawn:doe ratio becomes a meaningful indicator of deer herd population trends only when the survival rates of the various age classes are also known.

Fawn:Doe Ratios in the Southwest

Fawn:doe ratios have been determined on a statewide basis in Arizona since about 1956. The statewide ratios from 1956 to 1964 seemed low (0.42), an occurrence which, if real, might be associated with the effects of climate on habitat quality. Long-term variations in southwestern climate are suggested in figure 8 with tree ring data from 46 sites in Arizona and New Mexico. Tree ring data are summarized by 5-year periods from 1900 to 1964 as the percent of sites with tree ring widths less than 90% of normal. Tree ring data have not yet been summarized for the years following 1964. Patterns in tree ring widths reflect past variations in moisture and temperature which have the ability to limit growth processes within the tree (Fritts 1966). Reduced precipitation affects soil moisture and subsequently the water balance of the tree. High temperatures increase rates of evapotranspiration, respiration, and photosynthesis which can adversely affect both the production of forbs and leaf, bud, and fruit development on perennial woody species. These foodstuffs are important to deer since their presence influences the condition of does during mid and late gestation which can affect the survival of neonatal fawns and subsequent recruitment into the deer herd (fig. 7).

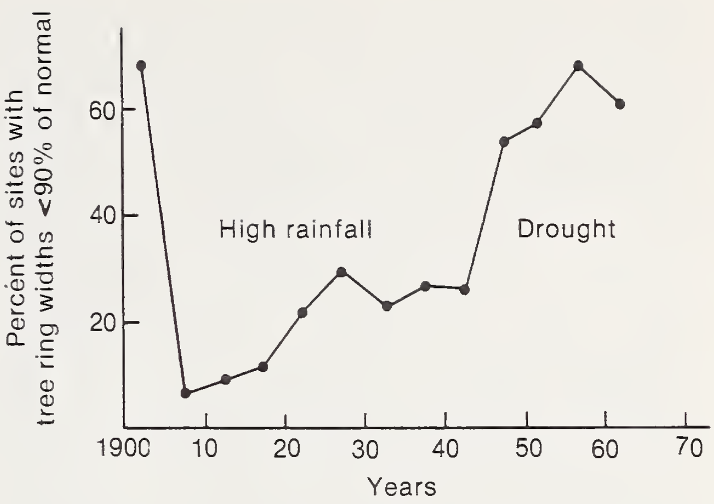

Figure 8.—Tree ring data indicate an extensive drought in Arizona and New Mexico during the mid-twentieth century.

Tree ring records in figure 8 indicate drought conditions from 1900 to 1904, mesic conditions from 1905 to 1920, followed by generally declining precipitation until 1945. An extensive drought period occurred from 1945 to 1964. The apparently low (0.42) Arizona fawn:doe ratios were determined during the last 9 years of this period. Increasing impact of civilization and hunting pressure in the Southwest unfortunately coincided with these unfavorable climatic conditions and this period of apparent limited deer productivity.

Fawn:doe ratios also vary by habitat type within a state. In Arizona, ratios for the north Kaibab and some southeastern game management units were significantly higher ($P < 0.05$) from 1956 to 1973 than were ratios for several central basin game management units. Portions of the forest and woodland areas of north-central and south-central New Mexico also seem to have higher fawn:doe ratios than other game management units in that state.

Survival Rates and Deer Herd Dynamics

There are 84 combinations—seven rates of fawn survival, four rates of yearling survival, and three rates of survival for mature does—represented in the simulations in table A4. Only 17 of the 84 combinations simulated for 10 years yielded doe populations that were at least 105% of the original doe population. Only six combina-

tions of survival rates yielded populations equal to 95-105% of the original population. Sixty-one of the 84 simulations reflect combinations of survival rates insufficient to maintain doe populations through 10 years with the fawn production rates utilized in these simulations. These results (figs. 9 and 10) indicate that herds like those simulated in the exercise increase only when the survival rates of adult does are high (90%) or when fawn and yearling survival rates are moderate to high (70-80%), and the survival rate of adult does is moderate (70%). Doe populations remain stable after 10 years when fawn and yearling survival rates are either moderate (60%) or high (80%) and doe survival rate is moderate (70%). Stable populations also occur when the adult doe survival rate is high (90%) and the survival rates of fawns and yearlings vary from low to high in several combinations.

The doe population decreases over time in about one-third of the simulations with high adult doe survival rates (because the fawn and yearling survival rates are low) in 85% of the simulations with moderate adult doe survival rates, and in all the simulations with a low adult doe survival rate (50%).

The most important variable in maintaining a deer population may be the survival rate of the adult does because they are the reproductively active segment of the herd. For the conditions of these simulations, any environmental pressure, including the shooting of does, that increases adult doe mortality will cause a decrease in herd numbers. If recruitment rates are limited, doe survival rates must be high in order to prevent a drastic decline in deer numbers.

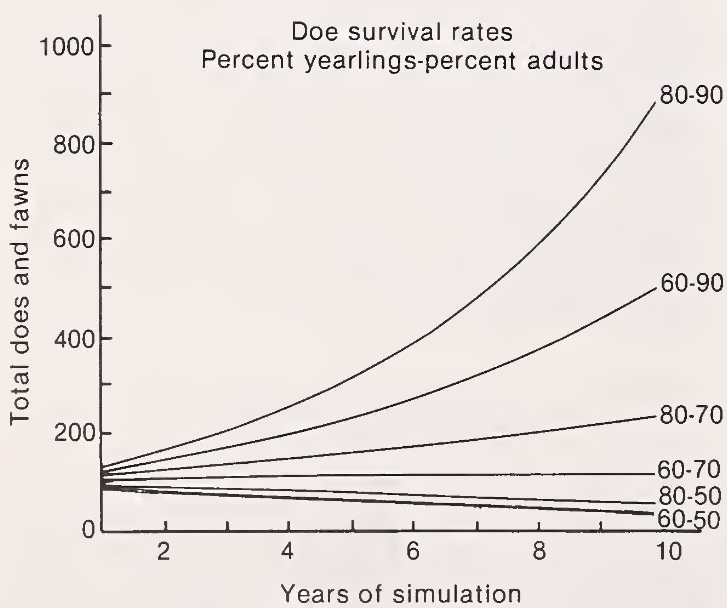

Figure 9.—Simulated changes in doe populations over 10 years when fawn survival rate is 80% and yearling and adult doe survival rates vary, part 1.

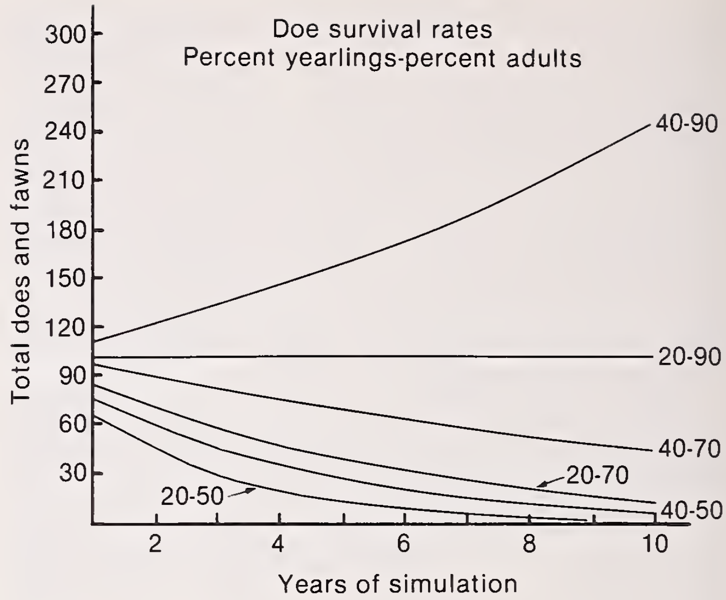

Figure 10.—Simulated changes in doe populations over 10 years when fawn survival rate is 80% and yearling and adult doe survival rates vary, part 2. Note change in ordinate scale from that in figure 9.

Midwest White-tailed Deer Population Simulation

The George Reserve, a 1200-acre fenced tract in southern Michigan, was stocked with two bucks and four does in March 1928. Counts in December 1933 indicated a population of 160 deer (Chase and Jenkins 1962). The eruptive productivity of the George Reserve herd has become legendary, and some subsequent deer management policies have been based on the assumption that the potential for recovery of deer numbers will quickly compensate for any errors of commitment.

It is difficult to simulate the growth of the George Reserve herd because the productivity of the individual age classes is not known. Sufficient information is available for some simulations to be made about productivity in the white-tailed deer herd in the Crab Orchard Wildlife Refuge in southern Illinois in order to develop baseline information. Productivity rates on the Crab Orchard Refuge (40 fawns:100 1-year-old does, 170 fawns:100 2-year-old does, and 185 fawns:100 older does; Roseberry and Klimstra 1970) are not as high as those apparently present on the George Reserve.

In the following simulation very high survival rates of 90% for 1-year-old does, 95% for adult does, 80% for 1-year-old bucks, and 85% for adult bucks have been used. The high survival rates are assumed to reflect the reduced mortality present within a fenced enclosure. The survival rate for the fawn crop was varied from 50% to 80% in the simulation. Expected herd in-

creases through 6 simulated years are presented in figure 11.

Central Arizona Mule Deer Population Simulation

A 600-acre deer enclosure on the Three Bar Wildlife Management Area near Roosevelt Lake in the central basins of Arizona was stocked in 1970 with three mule deer bucks, five does, and two fawns. Six years of data from the enclosure were available for the simulation presented in figure 11. Survival rates used for mule deer were the same as for the Crab Orchard white-tailed deer, and the usual productivity rate for mule deer in the Southwest of 100 fawns:100 2-year-old does and 150 fawns:100 adult does was used. Fawn survival for mule deer was varied from 40% to 80%. It is obvious from figure 11 that even when the survival of white-tailed fawns in a highly productive herd is only 50%, deer numbers increase at a greater rate than do southwestern mule deer herds with fawn survival rates as high as 80%.

The deer enclosure at Three Bar was constructed and stocked in order to determine the "natural rate of increase" for mule deer in the central basins, an area of apparently limited recruitment. If yearling and adult survival rates used in the simulation are similar to those actually occurring within the Three Bar enclosure, then observed deer numbers most nearly resemble that simulation curve in figure 11 with a fawn survival of 50%. Fawn survival outside the Three Bar enclosure may be even lower, suggesting that the central basins are an area where deer recruitment is quite limited.

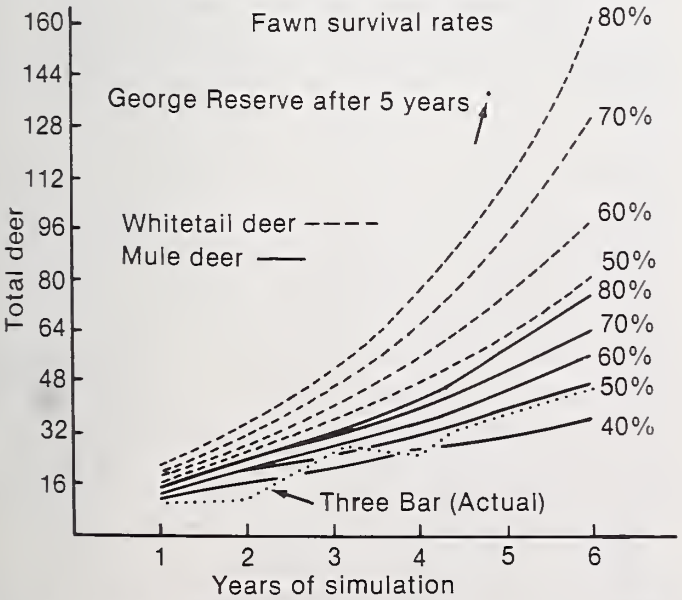

Figure 11.—Simulated rate of increase for a mid-western white-tailed deer herd and a southwestern mule deer herd. The observed rate of increase in the Three Bar deer enclosure is also indicated.

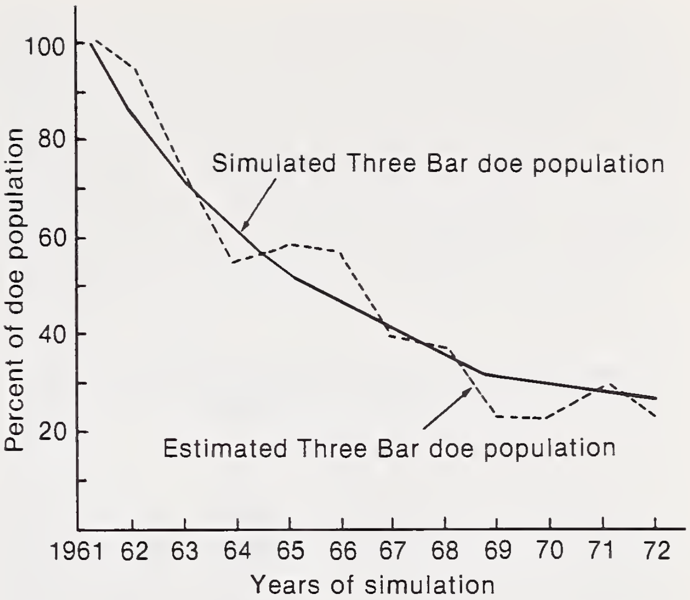

Figure 12.—Simulated versus observed changes in the deer population of the Three Bar Wildlife Management area in central Arizona.

After a simulated 6 years, the mule deer herd with a fawn survival rate of 80% was less than one-half the size of the white-tailed deer herd (fig. 11). It seems clear that harvesting tenets developed for eruptive white-tailed deer populations are not applicable to southwestern deer herds where fawn production, fawn survival, and herd recruitment rates are low.

The Three Bar deer herd can be used as an example of the consequences of using common management techniques when herd recruitment is low. The total Three Bar Wildlife Area consists of about 61 square miles of cattle-free deer habitat (Smith et al. 1969), 45 square miles of which are mule deer habitat. Estimates of the approximate size of the mule deer herd were made periodically from 1961 to 1972 from large scale pellet group surveys converted to approximate deer numbers. Buck:doe and fawn:doe ratios were determined by surveys in late autumn or early winter following the hunting season. These ratios were used in the simulation in figure 12. The observed fawn:doe ratio suggests a recruitment rate of about 30%. At this recruitment level doe populations increase slowly with 80% yearling survival and 90% adult doe survival (table A4) and remain unchanged with 80% yearling survival and 85% adult doe survival. The Three Bar deer herd was assumed to be static before antlerless deer hunting occurred; so survival rates of 80% and 85% for yearling and adult does were used in the simulation to reflect the condition prior to antlerless deer hunting.

There were about 700 does in the Three Bar herd in 1961 (Le Count 1974) when "heavy" antlerless deer hunting commenced. After 4 years

of "heavy" hunting (1961-1964), the doe population was only 400. Four years of "light" hunting (1965-1968) followed, and the doe population was further reduced to 200 (Le Count 1974). The total Three Bar mule deer population during this 8-year period dropped from 1300 to 300 animals.

After 4 additional years of buck-only hunting, the doe population was unchanged. The simulation in figure 12 assumes that legal kill and crippling of does from 1961 to 1964 ("heavy" antlerless deer hunting) increased doe mortality 15%, reducing yearling survival to 65%, and adult doe survival to 70%. The "light" antlerless deer hunting from 1965 to 1968 is assumed to have increased doe mortality 10%, thus reducing yearling survival to 70% and adult doe survival to 75%. These mortality rates are somewhat greater than those estimated for the same data by Smith et al. (1969). Yearling survival of 80% and adult doe survival of 85% were assumed for 1969-1972 when buck-only hunting occurred. It is obvious the greatest impact on the Three Bar deer herd was not the 350-400 does harvested over the 8-year period but the 3500-4000 fawns lost to the herd over the 12-year period because of the overall reduction in the doe population.

Northern Arizona Mule Deer Population Simulation

Another example of the apparent effect of antlerless deer hunting in areas with low recruitment is evident in northern Arizona, although the fluctuations in the regional deer herd are not as well documented as those for the Three Bar deer herd. Overuse of some Arizona deer ranges was obvious in the 1940's, apparently due to an increasing deer population following 40 years of adequate precipitation (fig. 8) and generally low harvests of the statewide deer herd by a limited hunting public. Tree ring data (fig. 8) indicate the late 1940's, 1950's, and early 1960's comprised the most extensive drought period of this century in the Southwest. By the latter half of this period, deer populations were relatively high, carrying capacities reduced, and there were some deer die-offs; for example, on the north Kaibab (Swank 1958). Deer recruitment during this period was low, and an extensive compilation of late autumn-early winter fawn:doe ratios indicated a ratio of only 40 fawns:100 does for Rocky Mountain mule deer. This ratio is achieved when a fawn survival rate of about 35% occurs.

Limited hunting of antlerless deer outside of the north Kaibab was first allowed in Arizona in 1949 (Jantzen 1964), and the extent of antlerless hunting gradually increased through 1952, increased substantially through 1958, and de-

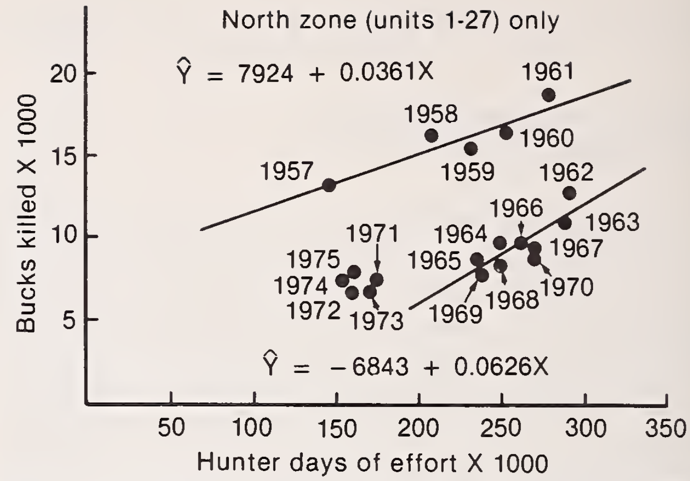

Figure 13.—Hunter effort required to kill buck mule deer in Arizona.

creased gradually through 1963. About 75,000 antlerless deer were harvested in northern Arizona (game management units 1-27) from 1952 to 1963 (Jantzen 1964). From the late 1950's until 1961 the antlerless deer kill was greatest and the buck kill gradually increased in proportion to increased hunting effort (fig. 13). Any residual buck population from years of underharvest, as well as the annual yield of buck deer, was being harvested. The buck kill in 1962 was only two-thirds that of 1961, even though hunting pressure remained constant. Buck kill per unit of effort was significantly less from 1962 to 1970 than from the late 1950's to 1961 ($P < 0.05$), presumably because the sustained yield of bucks was significantly diminished. It appears that this occurred because the productive doe population had been reduced critically by annual hunts of antlerless deer, even though that harvest had seemingly occurred at a modest rate.

The relationship between even modest increases in the mortality rates of does over an extended period and the decreasing mule deer herd in northern Arizona is further illustrated in figure 14. The simulated population originally contained 100 does (20 1-year old does, 40 2-year-old does, and 40 3-year-old or older does) that produced 100 fawns the first July. Values plotted represent deer numbers in January after the usual fawn mortality. Data from Rocky Mountain mule deer in northern Arizona would represent some multiple of these values. From 1956 to 1964 state personnel observed buck:doe:fawn ratios in late autumn and early winter of 35:100:42 in game management units 1-27. This fawn:doe ratio is achieved when a survival rate of about 35% occurs. A deer herd will sustain itself at this low level of recruitment only with high survival rates (e.g., 70-80% for yearling does and 85% for adult does). The first 5 years simulated in figure 14 correspond to the early 1950's when deer popu-

lations were at high levels and either slowly increasing or static. Survival rates were about 35% for fawns, 80% for yearling does, 60% for yearling bucks, 85% for adult does, and 65% for adult bucks. Years 6-15 of the simulations in figure 14 represent the period about from 1954 to 1963 when antlerless deer hunting was allowed and doe survival rates were consequently diminished. Years 15-25 are recovery years, when buck-only hunting occurred.

The 5% added doe mortality in figure 14 is probably a conservative estimate of the effect of antlerless deer hunting during a decade when the total legal antlerless deer kill in northern Arizona was over 68,000 (Jantzen 1964). After a simulated 10 years at this decreased doe survival rate, the deer population is only 60% of the original, suggesting that by the mid 1960's the northern Arizona deer herd could have been reduced by about 40%. The simulation indicates a buck:doe:fawn ratio little changed at 31:100:41.

The observed fawn:doe ratio in northern Arizona from 1965 to 1974 was 48:100. This ratio is achieved when a fawn survival rate of about 40% occurs. This fawn survival rate was incorporated into the simulation for the last 10 years. Survival rates for the other age classes remained the same as during the first 5 years of the simulation. After a simulated 25 years, corresponding to the mid 1970's, the deer population had slowly increased to about 80% of the fifth year (mid 1950's) level. Simulated buck:doe:fawn ratios were 38:100:46. Surveys done in the mid 1970's produced ratios of 27:100:48. This would indicate actual buck mortality was even greater than that reflected by the simulation.

Figure 14 also represents the population simulation realized if antlerless deer hunting during years 6-15 increased doe mortality by 10% instead of 5%. After a simulated 10 years of antlerless deer hunting, the deer population would be only 33% of the original. Little increase in the total population would be realized after 10 years of recovery.

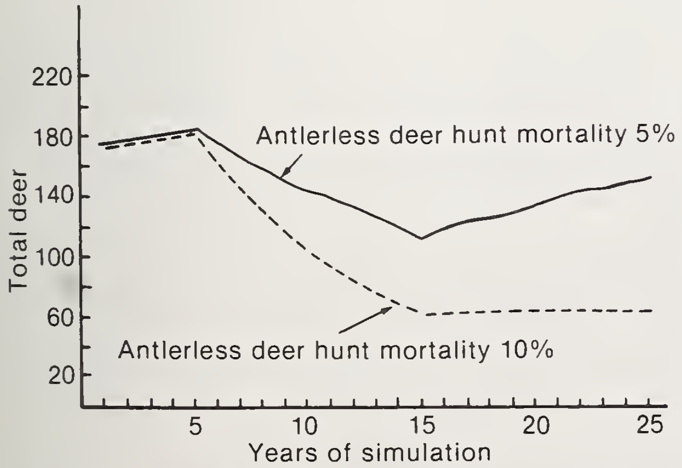

Figure 14.—Simulated changes in the Rocky Mountain mule deer herd of northern Arizona in relationship to the increased doe mortality resulting from antlerless deer hunting.

The simulations presented in figure 14 may offer a plausible explanation for the general changes in Arizona deer populations for the 20 years from the mid 1950's to the mid 1970's.

THE HUNTING OF ANTLERLESS DEER AS A MANAGEMENT TOOL

It is obvious that any decrease in the survival rates of fawn-producing age classes will effectively reduce a deer population. It is difficult to consider the hunting of antlerless deer in herds with limited recruitment as acceptable deer management, except as an isolated effort to reduce herds to range-carrying capacity. Although the killing of antlerless deer under conditions of limited recruitment provides some short-term recreational hunting, it may well be at the long-term expense of the deer herd.

The hunting of antlerless deer can be utilized to maintain deer population at desired levels when herd recruitment is high and herds are at range-carrying capacity.

The north Kaibab in Arizona represents a relatively rare management opportunity in the western United States. This legendary range comprises about 526,000 ha of which 162,000 ha are summer range (Russo 1970).

The north Kaibab deer herd presents game management personnel the opportunity to either maximize the harvest of the resource or concentrate on harvesting a very high quality product (i.e., the trophy buck). The forage, nutrients, and energy required to produce a trophy quality, mature buck are much greater than those required to produce a yearling buck (Short 1972). The decision concerning which management scheme to pursue requires an impressive understanding of the deer herd. Requiring hunters with permits for hunting antlerless deer to harvest only antlerless deer and restricting the number of bucks killed would tend to keep total deer numbers in check while yielding a long-age-structured buck population. High fees could be charged for permits to kill trophy bucks produced under these management conditions.

Hunting antlerless deer can, theoretically, maintain total deer numbers and still yield a relatively high proportion of trophy bucks when deer production rates are high. A deer herd that originally consists of 35 bucks, 100 does, and 100 fawns with 70% fawn survival will vary in size

Table 5.—The effect of different doe and buck survival rates (percent) on the production of trophy bucks (aged 3-1/2 years and greater) in the population after a simulated 10 years. Results are values recorded in January. Initial population was 35 bucks, 100 does, and 100 fawns born in July with a fawn survival of 70%

Doe survival rates		Buck survival rates		Results after 10 years		
Yearlings	Adults	Yearlings	Adults	Total deer	Total bucks	Trophy bucks
80	85	70	75	777	211	91
70	75	70	75	267	96	53
70	75	60	65	228	57	22

after a simulated 10 years dependent on the buck and doe survival rates (table 5). If doe survival rates drop from 80% to 70% for yearlings and from 85% to 75% for adults and the survival rates for bucks remain at 70% for yearlings and 75% for adults, a variety of changes occur within the deer population. After 10 years the total number of deer (267) will be about unchanged from the original population (235), but about 34% of the number expected (777) had the survival of the does not been modified. At the same time the total buck population (96) will be 45%, and the "trophy" buck (those 3-1/2 years old and older) population (53) will be 58% of that expected (211 and 91, respectively) had survival rates of the population not been reduced (table 5).

Hunters with antlerless deer permits frequently kill an antlerless deer only if they cannot find a buck. This may increase buck mortality since both hunters with permits for antlered deer and those hunters with permits for antlerless deer are trying for the same resource. The combination of reduced survival rates for both bucks and does will cause total buck and trophy buck populations to decrease at greater rates than the deer population itself. If, for example, buck mortality is always about 10% greater than doe mortality, then as doe survival rates drop from 80% to 70% for yearlings and 85% to 75% for older does, buck survival rates will drop from 70% to 60% for yearlings and 75% to 65% for older bucks. Total deer numbers (228) under these conditions become 29% of those expected (777) had survival rates not been changed, and total bucks (57) would be only 27% and trophy bucks (22) only 24% of the unmodified totals (211 and 91, respectively) (table 5). The percentage of trophy bucks in the total deer kill on the north Kaibab seems to have decreased under limited either-sex deer hunting similar to that discussed in this paragraph (fig. 15).

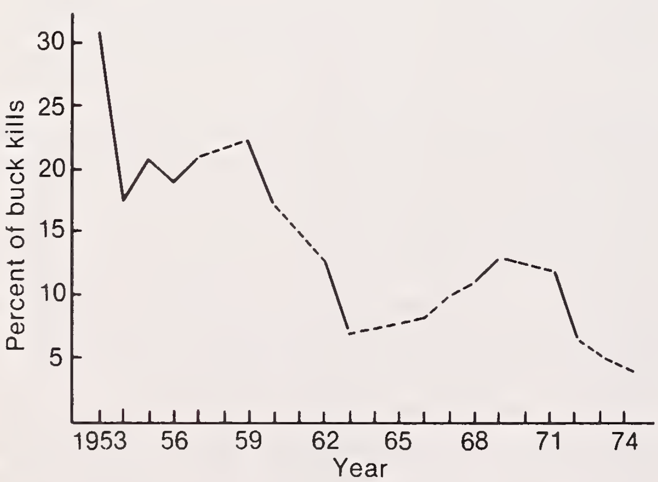

Figure 15.—Trophy bucks (3-1/2 years old and older) as a percent of the total deer kill on the north Kaibab, Arizona (from McCulloch 1975).

The hunting of antlerless deer is a valid management tool for maintaining a deer population within habitat-carrying capacity in deer herds with the high productivity rate of the north Kaibab herd. An increase of as little as 10% in doe mortality may be sufficient to hold the deer population in check. A larger increase in doe mortality rate may reduce the total deer population. A combination of antlerless deer hunting and heavy buck hunting will shorten the age-structure of the buck population and, consequently, reduce the number of trophy bucks on the range.

SUMMARY

It seems very likely that the limited productivity of many southwestern deer populations limits herd growth. Fetuses per doe and fawns per doe are frequently lower in the Southwest than in other deer herds. Deer management theories have often been based on deer populations with the potential to explode under favorable habitat conditions. These herds have high reproductive rates, good fecundity among young age classes, and high survival rates in fawn and yearling crops and considerable hunting pressure is required to keep population levels within habitat-carrying capacities. The situation in much of New Mexico and especially in Arizona seems to be one of only modest reproductive rates, limited fecundity in young age classes, and only fair sur-

vival of young deer. These populations approach habitat-carrying capacity very slowly. Heavy harvest, particularly of antlerless deer, may depress a deer herd for several years, rather than stimulate any increased reproductive response. Many southwestern deer herds apparently act as long-age-structured herds rather than short-age-structured herds and must, consequently, be managed more adroitly than populations with a greater capacity for growth.

Principles about the management of southwestern deer herds may be applicable to many other western herds. A first analysis suggests that many of these other herds have a greater fawn-production rate. If, however, high overwinter mortality of fawns is usual, then there may be greater similarity in the yield of yearling deer in western and southwestern deer herds than production data based on fetal counts would suggest. If this is the case, then the impact of hunting does in western herds would be similar to the impact to southwestern deer herds discussed in this paper. Interestingly, some herds of Rocky Mountain mule deer have apparently declined coincidentally with the introduction of the harvesting of antlerless deer. The dynamics of these western deer herds should be carefully analyzed to see if hunting antlerless deer is an adverse factor in local deer herd management. It is obvious the principles of deer management developed on the basis of some highly productive eastern deer ranges are not wholly applicable to management of the western mule deer.

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Appendix

Table A1.—Plant species eaten by southwestern deer at different seasons. Notation of L, M, or H usage indicates that a plant item composed 1-5%, 6-15% and 16% or more, respectively, of rumen contents. Literature references follow the table

Food items	Winter	Spring	Summer	Autumn	Reference no.[1]
Browse					
Quercus sp.	H	M	H	M	1,2,4,5,8,11,12
Juniperus sp.	H	L	M	M	1,3,6,11,12,13
Cercocarpus sp.	H	M	M	H	1,2,3,4,5,8,11,12
Yucca sp.	H	H	L	L	1,4,12
Rhus sp.	L	L	M	M	1,4,8,12
Garrya sp.	M	L	L	L	1,2,3,4,8,12
Artemisia sp.	L	L	M	M	1,4,6,13
Eriogonum sp.	H	L	L	M	4,5,6,8,10,11,13
Abies concolor	M		M	L	2,9,13
Prosopis sp.	L		M	L	4,5,10
Rhamnus crocea	M	M	L	L	4,5,11
Ceanothus sp.	M	M	L	M	4,5,7,11,12
Calliandra eriophylla	H	M	L	H	4,7,10
Pinus ponderosa	H	L	L	L	5,9,13
Pinus edulis	L			L	1,6
Gutierrezia sp.	L			L	1,6
Acacia sp.	L	H	L	L	4,10
Cowania sp.	M			M	6,13
Populus tremuloides			H	M	9,13
Nolina sp.	L	L			1
Fallugia paradoxa	L	L			1
Juglans sp.			L		1
Mahonia haematocarpa			L		1
Pseudotsuga menziesii				M	3
Simmondsia chinensis			L	M	4
Lonicera interrupta				L	4
Atriplex canescens				L	6
Mimosa dysocarpa			H	M	7
Picea engelmannii			L		9
Robinia neomexicana			L		9
Chilopsis linearis		L			10
Vauquelinia californica		L			10
Fouquieria splendens		L			10
Vitis arizonica				M	12
Krameria sp.		M	M		4,7
Phoradendron sp.	L	L	L	L	3,4,6,12,14
Opuntia sp. (fruit)	L	L	L	L	1,4,10
Carnegiea gigantea (fruit)			L		4
Ferocactus wislizenii	H	M	L	H	10
Agave sp.				L	12
Cholla sp. (fruit)	M			L	14
Forbs					
Baileya multiradiata		L			10
Descurainia pinnata		M			10,14
Lupinus sp.	L		L	L	4,6,7,13
Sphaeralcea sp.		L	L	L	1,4,6
Viguiera sp.			L	M	1,13
Penstemon sp.	L			M	4,6
Erigeron sp.			M	L	6,9
Lotus sp.			L	L	6,9
Agoseris sp.			L	L	7,9
Linum sp.	L			M	1
Euphorbia sp.	M	L	M		1,4

Table A1.—Continued

Food items	Winter	Spring	Summer	Autumn	Reference no.[1]
Dyssodia papposa			M		1
Melampodium leucanthum		L	L	L	1
Coreopsis tinctoria	L				1
Verbena sp.		L	L		1,10
Trifolium sp.			L		1,9
Salsola kali		L			1
Solanum xantii		L	L		4
Porophyllum gracile				L	4
Tradescantia occidentalis				M	4
Erodium cicutarium	L			L	4
Margaranthus solanaceus				L	4
Franseria confertiflora	L				4
Cuscuta sp.		M			4
Comandra pallida		L			4
Cordylanthus tenuifolius	L				5
Hymenopappus lugens				L	6
Delphinium andesicola			M	M	7
Cassia leptadenia			L	L	7
Polygonum aviculare			L		9
Eriastrum sp.		M			10
Apodanthera undulata			L		10
Potentilla sp.			M		13
Astragalus sp.		L	L	L	6,8,9,13
Ipomoea sp.			L	L	4,7,8
Physalis sp.			L		8
Dalea sp.		M	M	L	14
Desmanthus cooleyi		M	M		14
Commelina dianthifolia			M		14
Cucurbita foetidissima		L		L	14
Dichelostemma pulchellum		M			4
Grass and grasslike					
Gramineae	L	L	L	M	1,3,5,8,10,12
Bromus sp.	L		L	L	4,6,9
Agropyron sp.	L		L	L	5,6,9
Poa sp.			L	L	6,9
Sitanion hystrix	L	M			5
Bouteloua sp.			L	L	7
Dactylis glomerata			M		9
Other					
Mushrooms			M		13
Lichens	L			L	1

[1]References:
1. Anderson et al. 1965
2. Day 1961
3. Day and Welch 1959
4. McCulloch 1973
5. Neff 1974
6. McCulloch 1969
7. White 1961
8. Boeker et al. 1972
9. Hungerford 1970
10. Short 1977
11. Illige 1953
12. Day 1963
13. Wright 1950
14. Short et al. 1977

Table A2.—Approximate composition of the diet of southwestern deer in different habitats during different seasons

Deer species	Reference[1]	Habitat type	Season	Source	Shrubs and trees	Forbs	Grass and grasslike	Other	Total
White-tailed	1	Mixed conifer	Autumn	Rumen analysis	47				
	2	Mixed conifer—2287 m	Autumn	Rumen analysis	50 +				
	2	Below 2287 m	Autumn	Rumen analysis	74				
	3	Chaparral-desert	Winter	Rumen analysis	68	27	5		100
	3	Chaparral-desert	Spring	Rumen analysis	85	10	[2]	5	100
	3	Chaparral-desert	Summer	Rumen analysis	84	16	[2]		100
	3	Chaparral-desert	Autumn	Rumen analysis	49	48	3		100
	4	Ponderosa pine	Sum., aut., and win.	Percent feeding time	9	91			100
	4	Oak woodland	Sum., aut., and win.	Percent feeding time	97		3		100
Mule	3	Chaparral-desert	Summer	Rumen analysis	90	6	[2]	4	100
	3	Chaparral-desert	Autumn	Rumen analysis	92	8	[2]		100
	3	Chaparral-desert	Winter	Rumen analysis	75	21	4		100
	3	Chaparral-desert	Spring	Rumen analysis	66	24	[2]	10	100
	5	Unburned pinyon-juniper	Autumn	Rumen analysis	60	33	7		100
	5	Burned pinyon-juniper	Autumn	Rumen analysis	15	52	33		100
	6	Ponderosa pine	Summer	Percent feeding time	47	34	18	1	100
	7	Semi-desert grassland	Spring	Rumen analysis	42	23	3	32	100
	7	Semi-desert grassland	Summer	Rumen analysis	62	22	1	15	100
	7	Semi-desert grassland	Autumn	Rumen analysis	51	3	[2]	46	100
	7	Semi-desert grassland	Winter	Rumen analysis	37	4	1	58	100
	8	Pinyon-juniper	Yearlong	Estimated weight consumed	62	31	7		100
	8	Ponderosa pine	Yearlong	Estimated weight consumed	46	44	10		100
	9	Pinyon-juniper	Yearlong	Rumen analysis	70	26		4	100
	10	Pinyon-juniper	Yearlong	Rumen analysis	75	16	2	7	100
	11	Pinyon-juniper	Winter	Rumen analysis	94	2	1	3	100
	11	Pinyon-juniper	Spring	Rumen analysis	58	32	1	9	100
	11	Pinyon-juniper	Summer	Rumen analysis	51	42	1	6	100
	11	Pinyon-juniper	Autumn	Rumen analysis	87	4	4	5	100

[1]References:
1. Day 1961
2. Day and Welch 1959
3. McCulloch 1973
4. White 1961
5. McCulloch 1969
6. Hungerford 1970
7. Short 1977
8. Neff 1974
9. Anderson et al. 1965
10. Boeker et al. 1972
11. Short et al. 1977

[2]Trace

Table A3.—Productivity of different age classes of does from southwestern ranges

Range	Years	Reference[1]	Age classes	Number of does	Mean value per doe[2]
			months		
Mule Deer					
Guadalupe Mountains New Mexico	1957-58	1	15-17	100	0.01 c.a.
			27-29	105	0.88 c.a.
			39-53	73	1.12 c.a.
			63-99	67	1.55 c.a.
			99 +	56	2.04 c.a.
South Kaibab Arizona	1944-52	2	15		0.09 c.a.
			27		0.64 c.a.
			39-87		2.17 c.a.
			99 +		2.35 c.a.
	1953-54	3	15	20	0.05 c.a.
			27	17	0.88 c.a.
			39-63	25	1.64 c.a.
			75-99	21	2.19 c.a.
			99 +	8	3.13 c.a.
North Kaibab Arizona	1944-52	2	15		0.10 c.a.
			27		0.83 c.a.
			39-87		1.55 c.a.
			99 +		2.22 c.a.
	1953-54	3	15	161	0.0 c.a.
			27	62	0.81 c.a.
			39-63	187	1.46 c.a.
			75-99	133	2.41 c.a.
			99 +	166	2.83 c.a.
Three Bar Area Arizona	1962-66	4	33-96	12	1.25 F
Mingus Mountain Arizona	1954	3	15	8	0.0 c.a.
			27	8	0.88 c.a.
			39-63	8	2.50 c.a.
Moqui, Arizona	1953-54	3	15	15	0.0 c.a.
			27	42	1.05 c.a.
			39-63	48	1.77 c.a.
			75-99	54	2.63 c.a.
			99 +	22	4.14 c.a.
Santa Rita Experiment Range, Arizona	1969-71	5	0-12	5	0
			13-24	2	1.00 F
			25-36	0	0
			37-96	8	1.50 F
			97 +	2	0.50 F
Northern Utah	1954	6	Fawns	5	0.20 F
			15	7	1.38 F
			27	1	2.00 F
			39	1	2.00 F
			48-89	8	2.12 F
			99 +	4	2.25 F
Wasatch Front Utah	1950-53	7	15	128	1.11 F
			27	78	1.76 F
			39-87	234	1.70 F
			99 +	123	1.64 F
White-Tailed Deer					
Chiricahua Mountains Arizona	1955	8		33	0.79 c.a.
	1956	8		29	1.07 c.a.
	1958	8		61	1.11 c.a.
Fort Huachuca Arizona	1956	8		21	1.14 c.a.
	1959	8		17	0.94 c.a.

[1]References
1. Anderson et al. 1970
2. Illige 1953
3. Swank 1956b
4. McMichael 1967
5. This report
6. Jensen and Robinette 1955
7. Robinette et al. 1955
8. Day 1960

[2]c.a. = number corpora albicantia
F = number fetuses per doe

Table A4.—Simulated changes in herd size and structure after 10 years when different segments of the deer population survive at different rates. Original population consisted of 125 fawns, 10 yearling does, 20 2-year-old does and 70 3-year-old and older does. Yearling does are assumed to produce a single fawn at 24 months of age and mature does to produce an average of 1.5 fawns at 3 years of age and at 12 month intervals thereafter. The doe population after 10 years is listed as a percent of the original doe population. Yearling does are listed as a percent of total does in the population. Three right hand columns represent deer numbers and ratios measured in January

Annual survival rates			Fawn:doe ratio	Doe population (Y+A) after 10 years as percent of original Y+A	Yearling does (Y) as percent of Y+A does
Fawns (F)	Yearling does (Y)	Adult does (A)			
80	80	90	81	901	26
		70	76	224	28
		50	70	44	30
	60	90	86	498	22
		70	82	105	24
		50	74	19	26
	40	90	93	242	17
		70	90	40	18
		50	100	2	0
	20	90	104	99	10
		70	100	10	10
		50	0	0	0
70	80	90	73	676	24
		70	68	160	26
		50	64	28	29
	60	90	77	391	20
		70	73	77	22
		50	64	11	27
	40	90	84	196	15
		70	79	29	17
		50	0	0	0
	20	90	92	87	9
		70	100	6	0
		50	0	0	0
60	80	90	65	498	22
		70	61	105	24
		50	60	15	20
	60	90	69	296	18
		70	64	53	21
		50	67	6	17
	40	90	74	159	14
		70	70	20	15
		50	0	0	0
	20	90	80	75	8
		70	75	4	0
		50	0	0	0
50	80	90	56	356	19
		70	54	69	22
		50	44	9	22
	60	90	59	221	16
		70	57	35	17
		50	50	2	0
	40	90	64	121	12
		70	60	15	13
		50	0	0	0
	20	90	68	62	6
		70	75	4	0
		50	0	0	0

Table A4.—Continued

Annual survival rates			Fawn:doe ratio	Doe population (Y+A) after 10 years as percent of original Y+A	Yearling does (Y) as percent of Y+A does
Fawns (F)	Yearling does (Y)	Adult does (A)			
40	80	90	47	238	17
		70	45	40	18
		50	50	2	0
	60	90	49	160	14
		70	45	22	14
		50	0	0	0
	40	90	52	99	10
		70	44	9	11
		50	0	0	0
	20	90	55	51	4
		70	50	2	0
		50	0	0	0
30	80	90	37	160	14
		70	32	19	16
		50	0	0	0
	60	90	38	102	11
		70	33	12	8
		50	0	0	0
	40	90	40	75	8
		70	25	4	0
		50	0	0	0
	20	90	42	43	2
		70	0	2	0
		50	0	0	0
20	80	90	26	97	9
		70	22	9	11
		50	0	0	0
	60	90	26	74	8
		70	25	4	0
		50	0	0	0
	40	90	27	51	4
		70	0	2	0
		50	0	0	0
	20	90	28	36	3
		70	0	1	0
		50	0	0	0

Short, Henry L. 1979. Deer in Arizona and New Mexico: Their ecology and a theory explaining recent population decreases. USDA For. Serv. Gen. Tech. Rep. RM-70, 25 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

The hypothesis that declines in southwestern deer populations from late 1950's levels have been caused by relatively low fawn recruitment rates (because of habitat quality) combined with increased female mortality (because of antlerless deer hunting) is supported by computer simulations of the dynamics of southwestern deer herds.

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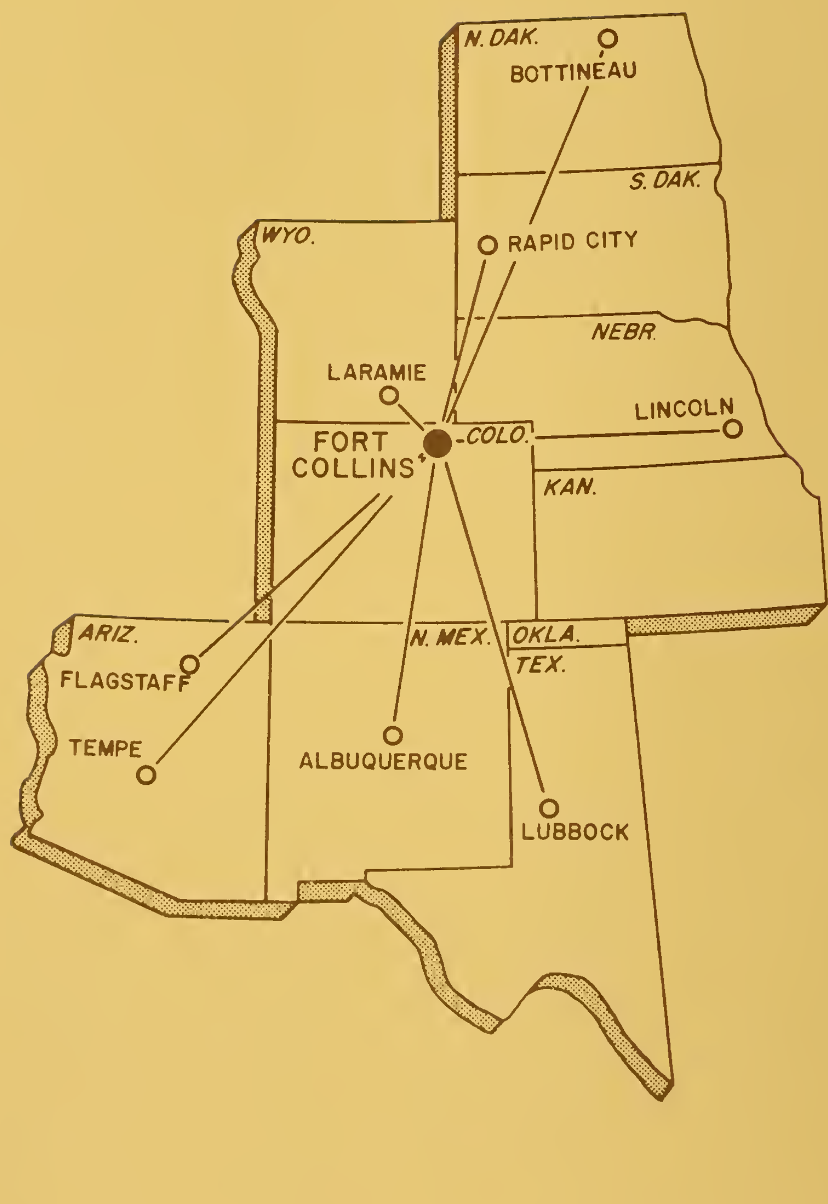
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